Saskatchewan
Agriculture
and Food

# ADF

## AGRICULTURE DEVELOPMENT FUND

## *FINAL REPORT*

19960237

# MARKET DEVELOPMENT INTO THERMOPLASTIC FILLERS

**Funded by: The Agriculture Development Fund**

**February 1998**

**Prepared by: Durafibre Inc.**

Final Report

96000237

# MARKET DEVELOPMENT INTO THE THERMOPLASTIC FILLERS

Funded by
The Agriculture Development Fund
March, 1998

Prepared by: Durafibre Inc.

The views expressed in this report are those of the author(s).
The Agriculture Development Fund (ADF) does not accept responsibility or liability for any conclusions or recommendations in the report, and cannot guarantee the accuracy of its data or observations.

ADF Project #96000237 / Res. 55BV

For

**Market Development into Thermoplastic Fillers.**

**Durafibre Inc.**

**Summary**:

The work was undertaken with the main objective to develop industrial products and applications for flax fibre and shive. The primary focus was the development of engineered flax fillers for the composite products. This is because composites are manufactured by a diverse group of industries for a broad range of applications, ranging from automotive to building components and furniture parts. Thus, composites represent excellent market opportunities for flax based fillers.

The determination of processing means for flax, chemical characteristics, fiber properties and performance of flax fibers in composites were the subject of the study. Both the Durafibre flax fibre and the shive were the materials investigated. Un-processed raw straw was included for some of the work to provide a basis of comparison between the starting materials and processed grades of flax fibre. Recent articles about flax fibre and flax-based products, which appeared in the scientific and technical literature, were reviewed. The laboratory research was performed at a University and the practical development work was performed at a development agency who has considerable expertise in this area.

**Technical Report**:

1. Project Activities and Achievements:

The morphological nature and chemical composition of the fiber influences many mechanisms that contribute to the properties and performance of reinforcing composites. These include, the dispersion and orientation of fibres in the matrix polymer, the compatibility of fibres to matrix polymer, the reactivity of fibres with additives, the resistance to microorganisms and the resistance to water uptake. For this reason, the first part of the research project was designed to obtain information on the morphological structure and chemical composition of flax fibres with a view to assessing their potential as reinforcing agents for polyolefins.

.... Page 2

Fiber reinforced thermoplastic composite technology is based on taking advantage of the stiffness and strength of fibers by dispersing them in a thermoplastic matrix, which acts as a binder and transfers stress from one fiber to another. The properties of the reinforcing composite are generally determined by the fiber characteristics, such as fiber stiffness and strength, fiber geometry and fiber length distribution. As well the fiber volume or loading, fiber orientation and the interface between the fibers and matrix polymer affect also the mechanical properties of the resulting composite. Fiber characteristics, not only affect the strength of the composites, they also have a direct influence on surface appearance of the composites and on the manufacturing processes. Fibre properties or characteristics are dependent on the method, starting raw material and raw material size. There are various methods of processing lignocellulosic materials into fibers. Each method generates fibers with particular characteristics. The purpose of the experimentation here was to identify the best available method of processing flax materials into fibres for these applications. The choice of the appropriate method will depend on the fibre size, fibre uniformity, fibre density and the ease of feeding the material into the compounding unit.

Using what had been found in prior testing, flax fiber reinforced thermoplastic composites were made. The objective of this section of the project was to investigate the processability of the thermoplastic polymers filled with flax fibers and to characterize the properties and performance of the resulting composites. The effect of various distinct various refining methods of flax materials into fibers and modifying agent concentration on the mechanical properties of the composites was investigated. The effect of flax fiber loading on the mechanical properties, thermal properties, water absorption, resistance to fungus and termite of the composite was also evaluated. High intensity thermokinetic mixer was employed to disperse flax fibers in the matrix polymer. Injection molding was used to process the compound materials into molded parts.

At the same time that this research was being performed at the University of Toronto, we were performing actual application tests on the flax fiber types at ISORCA to see how the various materials performed in an actual plant type incorporation trials. Compounds were produced in larger batch samples. Different formulas were reviewed to try to determine the best for the application. The objective of this program was to look at the feasibility of flax fibers and shives with development work in mind to see the usability in an actual plant utilization situation. No attempt was made to optimize any of the variables. Based on experience with glass fiber composites, we tried similar techniques with flax fiber and shive.

2. Results and Conclusions:

Flax fibers have unique physical and chemical properties. The chemical analysis of flax tissue revealed several useful facts some of them being that flax tissues are rich in extractives, they contain hydrophobic extractives, the lignin in the bast fibre portion is relatively low, and flax tissues are rich in hemicelluloses. These will both influence processing, properties and performance of flax-based composites.

..... Page 3

Four milling methods were investigated for the further refining of flax tissues and their conversion into fillers for composites. A method was determined to best process the flax materials that had been produced from the prior equipment used in Durafibre's fibre processing stages. They were able to generate relatively uniform fiber particles suitable for this application.

Composites were prepared with polypropylene and high density polyethylene matrix resins using different grades of flax fillers. It was determined that in lab tests the tensile and flexural properties of flax fiber-filled composites were significantly better than those of unfilled polymers. The properties of flax fiber-filled composites compared with those of other common commercial fillers.

The water absorption of flax based composites was comparable to that of wood flour composites. As a result it will be a concern in these flax applications.

In the termite exposure test flax-based composites performed well. After six weeks there was minimal evidence of termite attack on the composite.

In the 12 week fungal exposure test flax-based polymer composites showed variable responses to fungi. Depending on the flax filler level the affect of the fungi was very severe. Some of the loadings showed both weight loss and extensive fungal colonization.

Regarding the work at ISORCA they found to incorporate into a plant system it took much more effort and experimentation to get the Durafibre flax materials into the resin mixtures than had been expected. It was found that many attempts to mold panels resulted only in broken panels, panels that stuck to the mold, blistering due to residual moisture and other processing problems. Just learning to work with the Durafibre flax materials was a major part of the work that was performed. In the end they were successful in making some molded samples.

3. Indications for Further Development Work:

From this University research it was determined that more work is required into the specific investigated areas to try to solve the concerns in incorporating flax into composite applications. The research work proved that flax, on a lab scale basis, can be used in these applications. There will need to be modifications to the material to make it more usable in this market. Thus more research will be required.

After showing composite samples from ISORCA to some prospective customers, they seem to have interest in looking at development work which could lead to the incorporation of Durafibre flax materials in their business. Thus more development work is required in this area. The lower cost, lower density, ready availability and the feel of the flax materials excited potential customers.

Thus even though the results did not allow for immediate incorporation of Durafibre's flax materials into a commercial business, it proved that there is a reason to continue the investigation.

4. Impact of the Research:

If this application can be commercialized it could mean a very good market for the farmers flax straw to be utilized. It will take considerable time to do all the related research to address all the areas of concern and then to develop a market for this product. This research project has only started the work that will be required.

**Personnel**:

The research was performed by the University of Toronto as they seemed to have a good reputation in composite materials. They employed undergraduate students to perform much of the work. This meant that the work has dragged out much longer than had been expected.

The development work has been done by ISORCA as they have considerably more experience in these areas than the other development groups we looked at. As well they seem to have more contacts with potential clients whom could with time develop into actual customers of Durafibre.

**Equipment**:

No equipment has been purchased with funds from ADF.

**Expense Statement**:

See the attached statement of expenses.

Recognition to ADF has been through mention of their assistance in this work when we talk to potential customers.

Francis Kolla
Flax Fibre Marketing Manager
Cargill Limited.